Basics, TISE, 1D Box and LHO- CSIR

https://snboseplc.com/basics-tise-1d-box-and-lho-csir/

Q.No:1 CSIR-Dec-2014

Let ψ_1 and ψ_2 denote the normalized eigenstates of a particle with energy eigenvalues E_1 and E_2 respectively, with $E_2 > E_1$. At time $t = 0$ the particle is prepared in a state

$$\Psi(t=0) = \frac{1}{\sqrt{2}}(\psi_1 + \psi_2).$$

The shortest time T at which $\Psi(t = T)$ will be orthogonal to $\Psi(t = 0)$ is

1. $\frac{2\hbar\pi}{(E_2-E_1)}$
2. $\frac{\hbar\pi}{(E_2-E_1)}$
3. $\frac{\hbar\pi}{2(E_2-E_1)}$
4. $\frac{\hbar\pi}{4(E_2-E_1)}$

Q.No:2 CSIR-Dec-2014

Let $|\psi\rangle = c_0|0\rangle + c_1|1\rangle$ (where c_0 and c_1 are constants with $c_0^2 + c_1^2 = 1$) be a linear combination of the wavefunctions of the ground and first excited states of the one-dimensional harmonic oscillator. For what value of c_0 is the expectation value $\langle x\rangle$ a maximum?

1. $\langle x\rangle = \sqrt{\frac{\hbar}{m\omega}}, c_0 = \frac{1}{\sqrt{2}}$
2. $\langle x\rangle = \sqrt{\frac{\hbar}{2m\omega}}, c_0 = \frac{1}{2}$
3. $\langle x\rangle = \sqrt{\frac{\hbar}{2m\omega}}, c_0 = \frac{1}{\sqrt{2}}$
4. $\langle x\rangle = \sqrt{\frac{\hbar}{m\omega}}, c_0 = \frac{1}{2}$

Q.No:3 CSIR-Dec-2015

The ground state energy of a particle of mass m in the potential $V(x) = V_0 \cosh\left(\frac{x}{L}\right)$, where L and V_0 are constants (and $V_0 \gg \frac{\hbar^2}{2mL^2}$) is approximately

1. $V_0 + \frac{\hbar}{L}\sqrt{\frac{2V_0}{m}}$
2. $V_0 + \frac{\hbar}{L}\sqrt{\frac{V_0}{m}}$
3. $V_0 + \frac{\hbar}{4L}\sqrt{\frac{V_0}{m}}$
4. $V_0 + \frac{\hbar}{2L}\sqrt{\frac{V_0}{m}}$

Q.No:4 CSIR-June-2016

The state of a particle of mass m in a one-dimensional rigid box in the interval 0 to L is given by the normalised wavefunction $\psi(x) = \sqrt{\frac{2}{L}}\left(\frac{3}{5}\sin\left(\frac{2\pi x}{L}\right) + \frac{4}{5}\sin\left(\frac{4\pi x}{L}\right)\right)$. If its energy is measured, the possible outcomes and the average value of energy are, respectively

1. $\frac{h^2}{2mL^2}$, $\frac{2h^2}{mL^2}$ and $\frac{73}{50}\frac{h^2}{mL^2}$
2. $\frac{h^2}{8mL^2}$, $\frac{h^2}{2mL^2}$ and $\frac{19}{40}\frac{h^2}{mL^2}$
3. $\frac{h^2}{2mL^2}$, $\frac{2h^2}{mL^2}$ and $\frac{19}{10}\frac{h^2}{mL^2}$
4. $\frac{h^2}{8mL^2}$, $\frac{2h^2}{mL^2}$ and $\frac{73}{200}\frac{h^2}{mL^2}$

Q.No:5 CSIR-June-2016

The eigenstates corresponding to eigenvalues E_1 and E_2 of a time-independent Hamiltonian are $|1\rangle$ and $|2\rangle$ respectively. If at $t = 0$, the system is in a state $|\psi(t=0)\rangle = \sin\theta|1\rangle + \cos\theta|2\rangle$ the value of $\langle\psi(t)|\psi(t)\rangle$ at time t will be

1. 1
2. $(E_1\sin^2\theta + E_2\cos^2\theta)/\sqrt{E_1^2 + E_2^2}$
3. $e^{iE_1t/\hbar}\sin\theta + e^{iE_2t/\hbar}\cos\theta$
4. $e^{-iE_1t/\hbar}\sin^2\theta + e^{-iE_2t/\hbar}\cos^2\theta$

Q.No:6 CSIR-Dec-2016

Consider the two lowest normalized energy eigenfunctions $\psi_0(x)$ and $\psi_1(x)$ of a one dimensional system. They satisfy $\psi_0(x) = \psi_0^*(x)$ and $\psi_1(x) = \alpha\frac{d\psi_0}{dx}$, where α is a real constant. The expectation value of the momentum operator in the state ψ_1 is

1. $-\frac{\hbar}{\alpha^2}$
2. 0
3. $\frac{\hbar}{\alpha^2}$
4. $\frac{2\hbar}{\alpha^2}$

Q.No:7 CSIR-June-2017

If the root-mean-squared momentum of a particle in the ground state of a one-dimensional simple harmonic potential is p_0, then its root-mean-squared momentum in the first excited state is

1. $p_0\sqrt{2}$
2. $p_0\sqrt{3}$
3. $p_0\sqrt{2/3}$
4. $p_0\sqrt{3/2}$

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Q.No:8 CSIR-Dec-2017

The state vector of a one-dimensional simple harmonic oscillator of angular frequency ω, at time $t = 0$, is given by $|\psi(0)\rangle = \frac{1}{\sqrt{2}}[|0\rangle + |2\rangle]$, where $|0\rangle$ and $|2\rangle$ are the normalized ground state and the second excited state, respectively. The minimum time t after which the state vector $|\psi(t)\rangle$ is orthogonal to $|\psi(0)\rangle$, is

1. $\pi/2\omega$
2. $2\pi/\omega$
3. π/ω
4. $4\pi/\omega$

Q.No:9 CSIR-June-2018

The maximum intensity of solar radiation is at the wavelength of $\lambda_{\text{sun}} \sim 5000\ A^0$ and corresponds to its surface temperature $T_{\text{sun}} \sim 10^4 K$. If the wavelength of the maximum intensity of an X-ray star is 5 A^0, its surface temperature is of the order of

1. $10^{16} K$
2. $10^{14} K$
3. $10^{10} K$
4. $10^{7} K$

Q.No:10 CSIR-June-2018

At $t = 0$, the wavefunction of an otherwise free particle confined between two infinite walls at $x = 0$ and $x = L$ is $\psi(x, t = 0) = \sqrt{\frac{2}{L}}(\sin\frac{\pi x}{L} - \sin\frac{3\pi x}{L})$. Its wavefunction at a later time $t = \frac{mL^2}{4\pi\hbar}$ is

1. $\sqrt{\frac{2}{L}}\left(\sin\frac{\pi x}{L} - \sin\frac{3\pi x}{L}\right) e^{i\pi/6}$
2. $\sqrt{\frac{2}{L}}\left(\sin\frac{\pi x}{L} + \sin\frac{3\pi x}{L}\right) e^{-i\pi/6}$
3. $\sqrt{\frac{2}{L}}\left(\sin\frac{\pi x}{L} - \sin\frac{3\pi x}{L}\right) e^{-i\pi/8}$
4. $\sqrt{\frac{2}{L}}\left(\sin\frac{\pi x}{L} + \sin\frac{3\pi x}{L}\right) e^{-i\pi/8}$

Q.No:11 CSIR-Dec-2018

The standard deviation of the following set of data $\{10.0, 10.0, 9.9, 9.9, 9.8, 9.9, 9.9, 9.9, 9.8, 9.9\}$ is nearest to

1. 0.10
2. 0.07
3. 0.01
4. 0.04

Q.No:12 CSIR-June-2019

A quantum particle of mass m in one dimension, confined to a rigid box as shown in the figure, is in its ground state. An infinitesimally thin wall is very slowly raised to infinity at the centre of the box, in such a way that the system remains in its ground state at all times. Assuming that no energy is lost in raising the wall, the work done on the system when the wall is fully raised, eventually separating the original box into two compartments, is

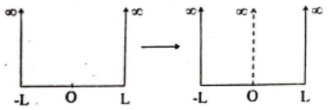


Figure 1: Figure for Q.No:12

1. $\frac{3\pi^2\hbar^2}{8mL^2}$
2. $\frac{\pi^2\hbar^2}{8mL^2}$
3. $\frac{\pi^2\hbar^2}{2mL^2}$
4. 0

Q.No:13 CSIR-June-2019

The wavefunction of a free particle of mass m, constrained to move in the interval $-L \leq x \leq L$, is $\psi(x) = A(L + x)(L - x)$, where A is the normalization constant. The probability that the particle will be found to have the energy $\frac{\pi^2\hbar^2}{2mL^2}$ is

1. 0
2. $\frac{1}{\sqrt{2}}$
3. $\frac{1}{2\sqrt{3}}$
4. $\frac{1}{\sqrt{\pi}}$

Q.No:14 CSIR-Dec-2019

A particle of mass m is confined to a box of unit length in one dimension. It is described by the wavefunction $\psi(x) = \sqrt{\frac{8}{5}}\sin\pi x(1 + \cos\pi x)$ for $0 \leq x \leq 1$, and zero outside this interval. The expectation value of energy in this state is

1. $\frac{4\pi^2}{3m}\hbar^2$
2. $\frac{4\pi^2}{5m}\hbar^2$
3. $\frac{2\pi^2}{5m}\hbar^2$
4. $\frac{8\pi^2}{5m}\hbar^2$

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Q.No:15 Assam CSIR-Dec-2019

The wavefunction of a particle in one dimension is given to be $\psi(x,t) = u(x)e^{-i\omega t}$, where $u(x)$ is

$$u(x) = \begin{cases} ax & 0 \le x \le 1 \\ \frac{1}{2}a(3-x) & 1 \le x \le 3 \\ 0 & \text{otherwise} \end{cases}$$

and $a > 0$. The expectation value of the coordinate $\langle x \rangle$ at time $t = 0$ is

1. 3/2
2. 1
3. 5/4
4. 3/4

Q.No:16 CSIR-June-2020

Let $|n\rangle$ denote the energy eigenstates of a particle in a one-dimensional simple harmonic potential $V(x) = \frac{1}{2}m\omega^2x^2$. If the particle is initially prepared in the state $|\psi(t=0)\rangle = \sqrt{\frac{1}{2}}(|0\rangle + |1\rangle)$, the minimum time after which the oscillator will be found in the same state is

1. $3\pi/(2\omega)$
2. π/ω
3. $\pi/(2\omega)$
4. $2\pi/\omega$

Q.No:17 CSIR Feb-2022

A particle of mass m is in a one dimensional infinite potential well of length L , extending from $x = 0$ to $x = L$. When it is in the energy Eigen-state labelled by $n, (n = 1, 2, 3, ...)$ the probability of finding in the interval $0 \le x \le L/8$ is 1/8. The minimum value of n for which this is possible is

1. 4
2. 2
3. 6
4. 8

Q.No:18 CSIR Feb-2022

The figures below depict three different wave functions of a particle confined to a one dimensional box $-1 \le x \le 1$

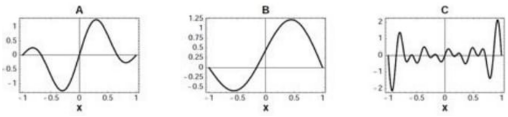


Figure 2: Figure for Q.No:18

The wave functions that correspond to the maximum expectation values $|\langle x \rangle|$ (absolute value of the mean position) and $\langle x^2 \rangle$, respectively, are

1. B and C
2. B and A
3. C and B
4. A and B

Q.No:19 CSIR Feb-2022

A particle of mass m in one dimension is in the ground state of a simple harmonic oscillator described by a Hamiltonian $H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2x^2$ in the standard notation. An impulsive force at time to $t = 0$ suddenly imparts a momentum $p_0 = \sqrt{\hbar m\omega}$ to it. The probability that the particle remains in the original ground state is

1. e^{-2}
2. $e^{-3/2}$
3. e^{-1}
4. $e^{-1/2}$

Q.No:20 CSIR Feb-2022

The unnormalized wave function of a particle in one dimension in an infinite square well with walls at $x = 0$ and $x = a$, is $\psi(x) = x(a - x)$. If $\psi(x)$ is expanded as a linear combination of the energy eigenfunctions, $\int_0^a |\psi(x)|^2 dx$ is proportional to the infinite series (You may use $\int_0^a t \sin(t)dt = -a \cos a + \sin a$ and $\int_0^a t^2 \sin(t)dt = -2 - (a^2 - 2)\cos a + 2a \sin a$)

1. $\sum_{n=1}^{\infty}(2n-1)^{-6}$
2. $\sum_{n=1}^{\infty}(2n-1)^{-4}$
3. $\sum_{n=1}^{\infty}(2n-1)^{-2}$
4. $\sum_{n=1}^{\infty}(2n-1)^{-8}$

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Q.No:22 CSIR June-2024

An atom of mass m, initially at rest, resonantly absorbs a photon. It makes a transition from the ground state to an excited state and also gets a momentum kick. If the difference between the energies of the ground state and the excited state is $\hbar\Delta$, the angular frequency of the absorbed photon is closest to

1. $\Delta\left(1+\frac{3}{2}\frac{\hbar\Delta}{mc^2}\right)$
2. $\Delta\left(1+\frac{1}{2}\frac{\hbar\Delta}{mc^2}\right)$
3. $\Delta\left(1+\frac{\hbar\Delta}{mc^2}\right)$
4. $\Delta\left(1+2\frac{\hbar\Delta}{mc^2}\right)$

Q.No:22 CSIR June-2023

In a quantum harmonic oscillator problem, $\hat{a}$ and $\hat{N}$ are the annihilation operator and the number operator, respectively. The operator $e^{\hat{N}}\hat{a}e^{-\hat{N}}$ is (where $\hat{I}$ is the identity operator)

1. $\hat{a}$
2. $e^{-1}\hat{a}$
3. $e^{-(\hat{I}+\hat{a})}$
4. $e^{\hat{a}}$

Q.No:23 CSIR June-2024

The Hamiltonian for a one dimensional simple harmonic oscillator is given by

$$H=\frac{p^2}{2m}+\frac{1}{2}m\omega^2x^2.$$

The harmonic oscillator is in the state

$$|\psi\rangle=\frac{1}{\sqrt{1+\lambda^2}}\left(|1\rangle+\lambda e^{i\vartheta}|2\rangle\right),$$

where $|1\rangle$ and $|2\rangle$ are the normalised first and second excited states of the oscillator and λ,ϑ are positive real constants. If the expectation value $\langle\psi|x|\psi\rangle=\beta\sqrt{\frac{\hbar}{m\omega}}$, the value of β is

1. $\frac{1}{\sqrt{2(1+\lambda^2)}}$
2. $\frac{\sqrt{2}\lambda\cos\vartheta}{1+\lambda^2}$
3. $\frac{2\lambda\cos\vartheta}{1+\lambda^2}$
4. $\frac{\lambda^2\cos\vartheta}{1+\lambda^2}$

Q.No:24 CSIR June-2024

The probability density function of a variable x is given by

$$P(x)=\frac{1}{2}\left[\delta(x-a)+\delta(x+a)\right].$$

The variance of x is:

1. a^2
2. 0
3. $2a^2$
4. $\frac{a^2}{2}$

Q.No:25 CSIR June-2025

The energy eigenstates of a one-dimensional harmonic oscillator are denoted by $|i\rangle$, where $i=0,1,2,3,\ldots$. If the momentum operator $\hat{p}$ satisfies

$$\frac{\langle n+1\,|\,\hat{p}\,|\,n\rangle}{\langle 2\,|\,\hat{p}\,|\,1\rangle}=\sqrt{2}$$

then the value of n is:

1. 0
2. 1
3. 2
4. 3

Q.No:26 CSIR June-2025

A particle of mass m is in the third energy eigenstate of an infinite potential well of width a. The time interval in which the phase of this wave function changes by 2π is

1. $\frac{4ma^2}{3\pi\hbar}$
2. $\frac{4ma^2}{9\pi\hbar}$
3. $\frac{8ma^2}{3\pi\hbar}$
4. $\frac{8ma^2}{9\pi\hbar}$

Q.No:27 CSIR June-2025

$|n\rangle$ denotes the eigenvector of the number operator for a particle of mass m in a one-dimensional potential $V=\frac{1}{2}m\omega^2x^2$, $n=0,1,2,\ldots$. For the state vector

$$|\varphi(x,t=0)\rangle=\frac{1}{\sqrt{3}}|1\rangle+\sqrt{\frac{2}{3}}|2\rangle$$

$\langle x(t)\rangle$ is

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1. $\frac{2\sqrt{2}}{3}\sqrt{\frac{\hbar}{2m\omega}}\cos\omega t$
2. $\frac{4}{3}\sqrt{\frac{\hbar}{2m\omega}}\cos\omega t$
3. $\frac{2\sqrt{2}}{3}\sqrt{\frac{\hbar}{2m\omega}}\cos 2\omega t$
4. $\frac{4}{3}\sqrt{\frac{\hbar}{2m\omega}}\cos 2\omega t$

Q.No:28 CSIR Dec-2025

A quantum mechanical particle in a harmonic potential has the wave function

$$\frac{1}{\sqrt{2}}\left[\psi_0(x)+\psi_1(x)\right]$$

at $t=0$, where $\psi_0(x)$ and $\psi_1(x)$ are the wave functions of the ground state and the first excited state, respectively. If the frequency of the oscillator is ω, the probability density of finding the particle at x after time $t=\frac{\pi}{\omega}$ is

1. $\frac{1}{2}\left|\psi_1(x)-\psi_0(x)\right|^2$
2. $\frac{1}{2}\left|\psi_1(x)+\psi_0(x)\right|^2$
3. $\frac{1}{2}\left|\psi_1(x)-i\psi_0(x)\right|^2$
4. $\frac{1}{2}|\psi_1(x)|^2+\frac{1}{2}|\psi_0(x)|^2$

Q.No:29 CSIR Dec-2025

one-dimensional quantum harmonic oscillator with frequency ω is in its ground state. Its normalised wave function is given by

$$\psi(x)=\left(\frac{m\omega}{\pi\hbar}\right)^{1/4}\exp\left[-\frac{m\omega}{2\hbar}x^2\right].$$

The frequency is suddenly increased to 2ω. The probability of finding the particle in its new ground state is

1. $\frac{2\sqrt{2}}{3}$
2. $\left(\frac{2\sqrt{2}}{3}\right)^{1/2}$
3. $\frac{2}{3}$
4. $\left(\frac{3}{2\sqrt{2}}\right)^{1/2}$

Q.No:30 CSIR June-2026

The eigen energies and the normalized eigenfunctions in the n^{th} state of a particle, confined in a one-dimensional infinite potential well, are denoted by E_n and ψ_n, respectively. If $E_1=1.2\,\text{eV}$, then the expectation value of energy in the state

$$\psi=3\psi_1+2\psi_2+\sqrt{3}\psi_4$$

is close to:

1. $5.5\,\text{eV}$
2. $5.0\,\text{eV}$
3. $4.5\,\text{eV}$
4. $6.0\,\text{eV}$

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Question No.	Entrance with year	Answer
Q.No:1	CSIR-Dec-2014	Option 2
Q.No:2	CSIR-Dec-2014	Option 3
Q.No:3	CSIR-Dec-2015	Option 4
Q.No:4	CSIR-June-2016	Option 1
Q.No:5	CSIR-June-2016	Option 1
Q.No:6	CSIR-Dec-2016	Option 2
Q.No:7	CSIR-June-2017	Option 2
Q.No:8	CSIR-Dec-2017	Option 1
Q.No:9	CSIR-June-2018	Option 4
Q.No:10	CSIR-June-2018	Option 4
Q.No:11	CSIR-Dec-2018	Option 2
Q.No:12	CSIR-June-2019	Option 1
Q.No:13	CSIR-June-2019	Option 1
Q.No:14	CSIR-Dec-2019	Option 2
Q.No:15	Assam CSIR-Dec-2019	Option 3
Q.No:16	CSIR-June-2020	Option d
Q.No:17	CSIR Feb-2022	Option 1
Q.No:18	CSIR Feb-2022	Option 1
Q.No:19	CSIR Feb-2022	Option 4
Q.No:20	CSIR Feb-2022	Option 1
Q.No:22	CSIR June-2024	Option 2
Q.No:22	CSIR June-2023	Option 2
Q.No:23	CSIR June-2024	Option 3
Q.No:24	CSIR June-2024	Option 1
Q.No:25	CSIR June-2025	Option 4
Q.No:26	CSIR June-2025	Option 2
Q.No:27	CSIR June-2025	Option 2
Q.No:28	CSIR Dec-2025	Option 1
Q.No:29	CSIR Dec-2025	Option 1
Q.No:30	CSIR June-2026	Option 1

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